2

SA-353

File No. 1-0001

CIVIL AERONAUTICS BOARD

AIRCRAFT ACCIDENT REPORT

ADOPTED: September 15, 1961 **RELEASED:** September 20, 1961

CAPITAL AIRLINES, INC., VICKERS-ARMSTRONGS
VISCOUNT, N 7462, NEAR CHARLES CITY, VIRGINIA
JANUARY 18, 1960

SYNOPSIS

At approximately 2219 e.s.t., January 18, 1960, a Capital Airlines Viscount, N 7462, en route from Washington, D. C., to Norfolk, Virginia, crashed and burned near Charles City, Virginia. All 46 passengers, including two infants, and the four crew members received fatal injuries.

N 7462 crashed in a wooded area, striking the ground in a level attitude, with no forward velocity.

The Board believes the accident was caused by the delayed arming of the engine ice-protection systems while flying through icing conditions, causing eventual flame-out of the four engines. This condition existed for sufficient time to cause a drop in battery electrical energy, preventing the unfeathering and relighting of sufficient engines to maintain flight. The aircraft was then dived in an effort to attain sufficient airspeed to drive the propellers out of the feathered positions by windmilling. At the same time, multiple attempts were made to relight one or more engines. Successful relights were either interrupted by auto-feather action initiated by premature advancing of the throttles prior to complete light up of an engine or prevented by insufficient battery electrical energy. No. 4 engine was eventually relit and the crew had just successfully relit No. 3 engine when the aircraft crashed.

As a result of this accident, Capital Airlines dropped the phrase "descend to warmer climate for relight" from its emergency checklist and instructed its Viscount pilots that relight could be accomplished at any altitude if proper drill were followed. Capital Airlines also adopted a system of checking pilots to ascertain that they had the benefit of the latest operating information.

Investigation

Capital Airlines Flight 20 of January 18, 1960, originated at Chicago Midway Airport and was to terminate at Norfolk, Virginia, with a stop at Washington, D. C. On this particular flight there was an aircraft change at Washington, D. C., at which time Viscount N 7462 was substituted for the original equipment. The assigned crew for Flight 20 consisted of Captain James B. Fornasero, First Officer Philip H. Cullom, Jr., and Hostesses Diane M. O'Donnell and Brigitte F. H. Jordt. There were 46 passengers aboard, including two infants.

At the time of dispatch, N 7462 had a basic operating weight of 40,155 pounds. The manifest shows 1,047 pounds of cargo, 44 passengers for 7,260 pounds, 401 pounds of water methanol, and 12,000 pounds of fuel for a total gross weight at takeoff of 60,863 pounds. It should have been 61,083 pounds due to the additional stewardess and company mail. The maximum takeoff gross weight for runway 18/36 at Washington National Airport is 64,500 pounds. The maximum takeoff gross weight for landing at Norfolk is 60,945 pounds.

The crew was briefed on the weather by the company dispatcher prior to departure.

Flight 20 departed the Washington National Terminal at 2130,[1/] and taxied to the runup block for runway 36. At 2135, the flight received its IFR clearance which read: "Capital 20 cleared to the Norfolk Airport via direct Springfield, Victor 3 to Brooke VOR, flight plan route, maintain 5,000 feet, cross Springfield at 3,000 feet, maintain 3,000 feet until two minutes past Springfield, cross Brooke at 5,000."

Flight 20 took off at 2140 and immediately switched to departure control frequency. There were no major discrepancies in the dispatching, loading or takeoff of the aircraft.

The flight proceeded to Springfield under departure control radar and switched to the Washington Air Route Traffic Control (ARTC) frequency when over Springfield. The Washington ARTC Center cleared the aircraft to climb to and maintain 8,000 feet.

Subsequently, Flight 20's clearance was amended to proceed via Victor 3 Brooke, Victor 286 Tappahannock, Victor 213 Hopewell, direct Norfolk, maintain 8,000 feet. The flight reported passing Brooke VOR at 2153 and estimated Tappahannock at 2202. Radar service was terminated at Brooke VOR, and the flight was requested to monitor Washington ARTC Center frequency until reaching Tappahannock, where it was to contact the Norfolk ARTC Center.

Flight 20 reported to Norfolk Center when over the Tappahannock low frequency range at 2201, at 8,000 feet, and estimated Hopewell VOR at 2212. At approximately 2205, four minutes past Tappahannock, the following clearance was issued to Capital Flight 20: "Capital 20 cleared to the Norfolk ILS Outer Marker from over Tappahannock, Victor Airway 213 Hopewell, then via the Hopewell 140 degree radial to Deep Creek, direct to the Norfolk Outer Marker, to maintain 8,000, contact Norfolk Radar on frequency 118.5 over Hopewell." The crew's acknowledgement of this clearance was the last radio contact with Capital Flight 20. All radio communications were normal, the pilot was making good his calculated groundspeed up to this time, and there was no indication of any difficulties.

Witnesses stated a low-flying aircraft executed two circles in a left pattern within a two-mile area of the impact site just prior to the time of the accident. The circles were made at increasingly lower altitudes. Many witnesses believed the aircraft was experiencing some type of engine difficulty. Application and removal of power, or cutting on and off of the engines, occurred at least three times. There was a final roar of power just before impact which occurred at approximately 2219.

1/ All times herein are eastern standard based on the 24-hour clock.

The wreckage area was located 8.4 nautical miles on a bearing of 067 degrees from the Hopewell VOR station. This is a point approximately 6.3 nautical miles east of the centerline of Victor 213 airway.

The wreckage was confined to the immediate area of impact, and no damage to the trees in the surrounding area could be found. All trees that did show impact damage were within the normal dimensions of the aircraft.

The aircraft struck the ground on a heading of 182 degrees magnetic, wings approximately level, and in a pitch attitude of about eight degrees noseup.

The wreckage was impaled on five trees, two through each wing and one through the tail cone. Sixty to 75-foot high trees also bracketed the nose, wings, and tail. Most of these trees showed no impact marks.

Shortly after impact, fire consumed the wreckage and caused considerable damage from the nose to the rear pressure bulkhead, as well as through the center wing section to just outboard of Nos. 1 and 4 engines.

There was no evidence of any structural failure prior to impact, and all wing failures and separations were due to ground conformity of the structures from impact and damage by intense and prolonged heat. All structure was accounted for at the wreckage. There was no evidence of in-flight fire.

The primary flight control surfaces were in good condition and operable, although damaged by heat and impact. The gust locks were found in the "OFF" position. The primary flight control systems, insofar as they could be checked, were also in good condition with no signs of damage or malfunction prior to impact. These systems were traced and inspected completely from the control surfaces to the center section spar. Fire damage prevented a complete examination forward of the spar; however, the critical areas, such as rod-end clevis fittings, were examined forward to station No. 92, where continuity was lost.

The trim tabs were set for: aileron-neutral; elevator one degree nose-up; rudder - three degrees nose-right.

The landing gear, flaps, and landing lights were in the retracted positions.

The inter-engine and crossfeed fuel valves were closed. The surface anti-icing system was off at both heat sources.

The No. 2 main and Nesa inverters showed evidence of rotation at impact. The No. 1 and emergency inverters showed no rotational impact marks.

Most of the propeller blades of each propeller were bent in various directions or missing from the hub. Nos. 1 and 2 propellers had a similar pattern of relatively light damage. Nos. 3 and 4 propellers suffered more severe blade distortion. No. 4 propeller blade root fixing was more severely damaged than that of No. 3 propeller. The positions of the propeller operating pistons indicated propeller settings as follows: No. 1 propeller - on feather-stop position of 84 degrees, 24 minutes; No. 2 propeller - on feather-stop position of 84 degrees, 24 minutes; No. 3 propeller - on flight-fine-stop position of 24 degrees; and No. 4 propeller - slightly above the flight-fine-stop position at 26 degrees.

All four powerplants were partially or completely buried in mud or water and were found in their correct positions in relation to the wing. Investigation revealed significant differences in the damage to engines Nos. 1 and 2, as compared with damage to engines Nos. 3 and 4. Engines Nos. 1 and 2 had few impact rotational rub marks appearing on the turbine and compressor assemblies. There were no bent or displaced vanes on the first and second stage impellers of these engines. However, these engines did have static press marks on reduction gearing made at impact by the transfer housing retaining studs. Impact damage occurring in the compressor sections of these engines was very light, and the eye casings were not damaged by rotational forces. The torsion shafts of the compressors had not failed.

Investigation of Nos. 3 and 4 engines revealed significant radial rub marks on reduction gearing and transfer housing retaining studs. The impact damage occurring in the compressor sections of these engines was very heavy. The impellers had some rotational damage. The eye casings had been rubbed by the rotating guide vanes. Both torsion shafts and both second stage impeller shafts had failed. There was also evidence of radial rub marks on the face of the turbine discs, and metal spatter was present on the nozzle guide vanes and turbine blades of Nos. 3 and 4 engines.

The hot-air gate valves for the four engines were found in closed position.

At 1900, January 18, 1960, there was a low pressure center at the surface over eastern Michigan and the Lake Erie area. A broad flat trough extended from the low center southeastward to a developing low over southeastern Virginia. A cold front extended from just north of Raleigh, North Carolina, to Tampa, Florida, while a warm front had moved northward along the coast to a position along the Virginia-North Carolina border. By 2200, the cold front was located between Blackstone and Norfolk, Virginia, while a deepening low was centered about 100 miles east of Delaware Bay with a trough extending back to southeastern Virginia.

The pertinent aviation area forecast prepared by the U. S. Weather Bureau and valid at the time of the accident called for obscured sky conditions with ceilings between 100 and 400 feet and visibilities ranging from 1/8 to two miles in light drizzle and fog over Virginia, eastern Maryland, Delaware, and northeastern North Carolina, with conditions slowly improving from the southwest after midnight. The forecast also indicated a chance of a few thunderstorms over the coastal waters of southeastern Virginia and eastern North Carolina until midnight.

The freezing level was forecast to be between 4,000 and 5,000 feet over eastern West Virginia, and sloping to 8,000 to 9,000 feet over eastern North Carolina, and lowering to the surface over eastern West Virginia and western Maryland by midnight. Moderate to heavy icing in the clouds was expected in the vicinity of a developing low over the coastal waters of southeastern Virginia and eastern North Carolina. Light to moderate icing (predominantly rime) in clouds above the freezing level was forecast for eastern West Virginia, western Maryland, and the mountainous sections of Virginia.

Upon departure of N 7462 from Washington National Airport, the local weather was reported as: measured 600 feet broken, 7,000 feet overcast; visibility five miles in fog. Ground stations nearest the proposed route reported ceilings ranging mostly from 100 to 400 feet and visibilities from five miles to less than one mile in light rain or drizzle and fog. Conditions at Richmond during the flight changed

very little with the ceiling measured at 200 feet and the visibility two miles in light rain and fog. Conditions at Norfolk were improving. At 2131, Norfolk reported an estimated ceiling of 700 feet broken, 6,000 feet overcast; visibility four miles in fog. At 2231, there were scattered clouds at 700 feet and 1,600 feet, and an overcast at 6,000 feet with visibility of six miles in fog.

Available pilot reports and radar reports indicated that cloud tops between Washington and the accident site were between 10,000 and 13,000 feet. The pilot reports showed layered clouds on the route with the base of the upper layer about 6,000 feet, and the tops of the lower layer between 3,000 to 4,000 feet. A few of the available pilot reports indicated mostly light to moderate turbulence over central and southern Virginia. There was one report of moderate to heavy turbulence at 6,000 feet over Salisbury, Maryland, at 2144, and a report of moderate to severe turbulence at 5,000 feet, just south of Lawrenceville, Virginia, at approximately 2045. Heavy rain showers were reported in flight between Richmond and Lawrenceville, while severe turbulence was reported in the vicinity of Langley Air Force Base about 2230. A pilot letting down into Norfolk, Virginia, about 2230 reported turbulence, heavy rain, and short periods of hail. Moderate to heavy rain showers were observed by groundwitnesses in the general area of the accident site about one to two hours prior to the accident. These groundwitnesses indicated, however, that at the time of the accident there were, at most, scattered light showers in the area, while some sections were affected by fog, which occasionally was heavy enough to produce light drizzle. Little or no wind was reported, and thunderstorms had not occurred at any time during the evening. Groundwitnesses in the Yorktown-Newport News, Virginia, area reported high gusty winds, heavy rain showers, hail, and possible thunder at about 2220 to 2230.

Flash Advisory No. 6 issued at 1700 January 18, at Washington, D. C., and valid from 1820 to 2210, indicated increasing shower and thunderstorm activity over Virginia and North Carolina coastal sections and adjacent waters with severe turbulence and hail aloft, and moderate to heavy icing in precipitation between 10,000 to 17,000 feet as a wave developed off the coast. Ceilings were forecast to be generally below 500 feet and visibilities less than two miles over the coastal waters and westward over Delaware, Washington, D. C., Maryland, and Virginia, to the Appalachians, including eastern North Carolina. Flash Advisory No. 7 issued at 2130 at Washington, D. C., and valid from 2210 January 18 until 0210 January 19, indicated that over Virginia, Maryland, and Delaware, east of a line from Norfolk, Blackstone, Gordonsville, Virginia; Martinsburg, West Virginia; north to the Pennsylvania border, ceilings would be below 800 feet and visibilities one to three miles in occasional rain, drizzle, and fog. Conditions were expected to improve from the southwest. Frequent moderate and locally severe turbulence was forecast over and near the mountains of West Virginia, Maryland, and Virginia.

Captain Fornasero was briefed by the company dispatcher via telephone on the weather conditions between Washington and Norfolk. He was given the 2030 amended terminal forecasts, the Washington Flash Advisory No. 6 valid until 2210, and four pilot reports. He was then given the 2100 sequence weather reports for Washington, Richmond, Newport News, Raleigh, Norfolk, Oceana, Norfolk Navy, and Patuxent River.

The refueling of Flight 20 was investigated to determine whether there might be a possibility of contamination or water ingestion into the fuel tanks during the last refueling activity. This investigation resulted in negative findings, insofar as could be determined by Bureau of Standards tests of fuel samples and by examination of the personnel and facilities of the refueling contractors.

Electric heating elements are built into the engine and oil-cooler air intakes of the Viscount as an ice-protection system. This system is controlled by switches on the roof panel of the cockpit. The system is not fully operative when on the ground, as a switch operated by the landing gear strut prevents overheating. With the switches in the "ON" position, the operation of this system is automatic.

Incorporated in the engine cowl ice-protection system is a thermostat for each engine. Each thermostat is located in the inlet duct of the cabin inter-cooler which is in the belly of the aircraft. In order to complete the electrical circuity of this system, the arming switches in the cockpit must be placed in the "ON" position, and the outside air temperature must be plus 5°C or cooler. This temperature at the thermostat location will permit the thermostat to close a switch completing the circuit to the units.

Each individual thermostat senses outside air temperature and varies the heating from a rapid and short cycle (fast) to a slow and lengthened cycle (slow). The fast cycle of two minutes duration occurs between ambient temperatures of plus 5°C and minus 6°C; the slow cycle of six minutes duration occurs at temperatures below minus 6°C.

The four "ON-OFF" switches on the left side of the overhead panel which control the cyclic motor have a dual purpose. In addition to energizing the cyclic motor and thermostatic circuits, they also serve as thermal resets in the event of an overload or unbalanced element circuit.

A green indicating light is provided beneath each switch to indicate the status of the cyclic motor and element circuits. When the circuit is normal with balanced elements and the cyclic motor is operating, the green light will glow continuously, varying in intensity as elements cycle "ON" and "OFF". At temperatures between plus 5°C and minus 6°C (fast cycle), the lamps will glow bright for three seconds, and dim for 1-1/2 seconds. At temperatures below minus 6°C (slow cycle), the lamps will glow bright ten seconds and dim for five seconds.

The heating elements of the power unit ice-protection system are designed to melt off ice in small pieces, which normally have no noticeable effect on operation when they enter the engine. However, if ice is allowed to build up to a considerable thickness before being removed, large pieces of ice enter the engine. The resultant high concentration of water may cause a partial or complete flameout.

A partial flameout, i.e., one or more combustion chambers extinguished, or a complete flameout will be indicated by reduction of torque pressure and jet pipe temperature (JPT).

Tests conducted during the development of similar Dart engines disclosed that the engines would flame out from ingestion of from 3.5 to four pounds of airframe ice, which is equivalent to the release of between a 1/4 and 1/2 inch thickness of ice from the inside part of the nose cowling.

Prior to July 1958, the operation of the ice-protection system of the Viscount was initiated or armed when the outside air temperature was at plus 5°C. Because of the experience of several operators of Viscount aircraft, and because

the temperature sensing on early aircraft was located in the aircraft nose section and was subject to compressibility error, temperatures at which the system would be armed were changed in July of 1958. After that date the prescribed procedure was to turn the system "ON" whenever the outside air temperature dropped to below plus 10°C. This modification, known as Change 15 of the Air Registration Board (ARB) Manual, had the sanction of the United Kingdom ARB and became a mandatory change for all United States air carriers using Viscount aircraft.

Change 15 also established the following procedure should icing conditions be encountered before the ice-prevention system could be switched "ON".

"1. Switch 'ON' ice-protection systems on Engines 1 and 3.

"2. Observe that the cycling lights indicate correctly.

"3. If both engines run normally for three minutes, switch 'ON' the ice-protection systems on Engines 2 and 4.

"4. If descending into air conditions where the temperature is above 0°C indicated, it is advisable to discontinue the descent until all four engines are running normally, i.e., for six minutes."

The Capital Airlines Flight Manual did not include the information about selective de-icing of engines that had accumulated a buildup of ice prior to arming the ice-protection system, nor did it make note of the inadvisability of descending into temperatures above 0°C until the ice-protection system had been turned on and the engines operated normally for a period of at least six minutes. In fact, the checklist in effect at the time of the accident directed the pilot to descend to warmer air to de-ice his engines normally. This checklist, effective March 26, 1957, reads as follows:

"Flame Out - In Icing Conditions

"1. Feather propeller.

"2. Relight immediately, or descend below the freezing level to allow the engines to de-ice naturally."

Each of the four engines of the Viscount is equipped with a propeller that incorporates an individual auto-feathering feature. The propellers will auto-feather at any time the throttle setting is calling for an engine output of 13,400 r.p.m or above and there is a loss of torque below 50 p.s.i. During the relight sequence, if the throttle should be moved from idle to cruise before the engine r.p.m. reaches 13,400 r.p.m., and/or the torque does not build up to 50 pounds p.s.i., the propeller will return to feather.

If the throttles are retarded to a point below 13,400 r.p.m. and a flame-out occurs, the propeller will simply windmill. Under this condition, if the throttles are then advanced to a position above 13,400 r.p.m. the propellers will auto-feather.

If an attempt is made to relight by actuating the unfeather switch, but without closing the high pressure cock and throttle, the propeller will not unfeather.

The propeller can be manually feathered by moving the high pressure valve lever to the feather position and then depressing the feather switch for each engine. When the feather/unfeather switch is manually pulled, the feather pump operates to supply oil pressure to unfeather and the air-relight circuit is energized to start the high energy igniters for 30 seconds.

Subsequent to the accident, a flight test was conducted in a Viscount 700 series aircraft in an effort to establish the average battery life of the type used aboard N 7462 when no generator power is available and while approximating the electrical load which was believed to have been carried at the time the emergency occurred. The flight test revealed that, with the four generators "OFF" and a continuous electrical load of over 500 amps., presumed to be about the same electrical load as that of the flight involved, the aircraft battery would fall, within 1-1/2 to two minutes, to below the required voltage necessary to successfully unfeather a propeller and relight its engine.

The flight test further revealed the comparative airspeeds required to drive the propellers out of feather by windmilling. Approximately 150 knots of airspeed were required to drive the outboard No. 4 propeller out of feather, and approximately 180 knots of airspeed were required to drive the inboard No. 3 propeller out of feather position.

Analysis

Shortly after departing from Washington, Capital Flight 20 would have been in the clouds and would have remained in the clouds during a substantial portion of its climb to the cruising altitude of 8,000 feet. While the aircraft probably was out of clouds a portion of the time en route, it is considered that it was in clouds more than half of the time or approximately 10 to 15 minutes. During this period and prior to descent near the accident site, the aircraft would have been experiencing subzero temperatures. At the same time, Flight 20 would have encountered light and occasionally moderate showers.

Cloud tops along the route were generally from 10,000 to 13,000 feet and could well have been lower locally. Ceilings ranged mostly between 100 and 400 feet with visibilities five miles or less in fog. Clouds were layered with the base of the upper deck about 6,000 feet and the tops of the lower deck between 3,000 and 4,000 feet. Drizzle was associated with the fog at a number of locations, while rain showers of varying intensity occurred along the route.

A small but intense low-pressure system and its associated frontal structure moved northeastward from south of the accident site to a location about 35 miles east-southeast of the site at the time of the accident. This system was accompanied by high gusty winds, heavy showers, turbulence, and some thunderstorm activity and hail. Pilot reports, radar reports, and groundwitness statements indicated quite clearly that the latter weather conditions affected neither the immediate area of the accident site nor the route from Washington to the accident site.

The freezing level in the Washington area was near 5,000 feet, while the temperature at 8,000 feet was minus 8°C. The temperature at 8,000 feet over the accident site was approximately minus 4°C, and the freezing level was near 6,000 feet.

Upon descending below 6,000 feet near the accident site Flight 20 would have encountered temperatures above freezing. The aircraft would have broken out of the

upper cloud deck at this altitude and would have entered the lower clouds at about 3,000 to 4,000 feet. From this altitude to ground impact the aircraft would have been in clouds with the possible exception of the final 100 to 400 feet. Light-to-moderate turbulence would have been encountered en route.

An analysis of the weather indicates the temperature and moisture content of the air at 8,000 feet, Flight 20's assigned altitude, were conducive to icing to the extent that 1/4 to 1/2 inch of airframe ice accumulation could have built up on the portions of the airframe of N 7462 while en route to the accident site.

In the investigation of this accident, the Board undertook to determine the number and reasons for the known instances in which Rolls-Royce Dart engines inadvertently shut down in flight. The review shows that the reasons for engines losing power simultaneously have been generally due to either late selection of the anti-icing equipment, or to fuel starvation caused by ice formation in the fuel lines, and/or the presence of a large amount of water in the fuel. There have been a total of 18 reported cases involving 18 airplanes in which multiple engine loss of power has occurred. However, in all of the instances which deal with late selection of the anti-icing equipment, the engines either recovered normally or were successfully relit. It was only in the cases - eight in number - which were concerned with ice in the fuel line or excessive water in the fuel that difficulty with relighting occurred. This information is based on reports received by Rolls-Royce from airlines on a worldwide basis and covering approximately 11 million engine flying hours.

All refueling activities of Flight 20 were investigated and found to be negative as far as contamination of fuel was concerned. The investigation also revealed that the hot-air gate valves of the four engines were in the closed position at the time of impact. Had a blockage in the fuel lines existed due to ice, the hot-air gate valves would have automatically opened to permit the hot air to pass to a heater in the fuel supply line.

Since there appears to be no evidence of fuel starvation or fuel contamination, the Board's investigation directed careful scrutiny to the possibility that Flight 20 experienced flameout of a sufficient number of its engines to preclude flight.

The principle of the anti-icing equipment aboard Flight 20 is to permit a small buildup of ice on the engine cowls of each engine and then to turn on the electrical current to actuate the engine cowl anti-icers so that the ice breaks off and goes into the engine. Early testing of the cowl anti-icing system was directed towards determining the correct length of time which the anti-icing equipment should be "ON" and the length of time which the heat to the cycle-heated pads of the engine cowl should be "OFF". As a result of this testing, a cycling time was selected and incorporated in the present Viscount cowl anti-icing system. This system, when armed, would be able to combat the worst icing conditions. The anti-icing installation aboard Flight 20 was approved by both the British Air Registration Board, and the American Civil Aeronautics Administration (FAA) as fulfilling the necessary requirements for such a system.

To avoid excessive accumulation of ice on the power units of the Viscount, the power unit ice-protection system should be switched "ON" during every flight at all times when the indicated outside air temperature is below plus 10°C, except when it is certain that icing conditions will not be encountered. One of the first visual indications of ice is its formation on the windshield wipers. By the time this is

apparent, a fair amount of ice could have accumulated on the engine cowls. The anti-icing system should be turned on well in advance of anticipated icing conditions in order to allow the inlet duct to warm up enough to prevent excessive ice from forming. If ice has been allowed to accumulate and the system is armed late, heating underneath the ice formation is quite rapid since the ice acts as an insulator. If ice has formed and the ice-protection system is turned on, sufficient heating occurs in approximately 30 seconds and de-icing will result. Under these circumstances, there is a good possibility that the entire ice accumulation around the inlet duct circumference will slip off and go through the engine en mass. The release of a large amount of ice from the inside part of the nose cowling, due to the late arming of the engine ice-protection system, would have been sufficient to flameout any of the engines.

The Board is aware that it has no factual information as to the precise sequence of events which occurred at 8,000 feet when Flight 20 began to sustain difficulty. However, the facts the Board does have support a probable sequence of events.

Capital Flight 20 reported over Tappahannock low-frequency range at 2201, at 8,000 feet, and estimated Hopewell VOR at 2212. At this time the Norfolk ARTC Center transmitted a clearance to Flight 20, clearing it to the Norfolk ILS Outer Marker from over Tappahannock. This transmission was completed at approximately 2205, at which time nothing of an unusual nature was reported aboard the aircraft. The accident site is approximately 40 nautical miles south of Tappahannock, and approximately 14 minutes elapsed between the completion of the transmission and impact, which occurred at approximately 2219. During this period of night flight, the crew of Flight 20 was confronted with a sudden emergency which required their complete attention, to the extent that no attempt was made to contact anyone by radio for the purpose of either declaring an emergency or requesting descent to a lower altitude.

The Board believes that at some period of time between 2205 and 2219, all four engines of the aircraft ceased to deliver power and their propellers feathered. The Board believes that this was due to the late arming of the ice-protection system. The first flameout could have been followed immediately by other flameouts or there could have been an undetermined period of time between the flameouts. The delay in arming the ice-protection system was probably due to one or more of the following factors: (1) Captain Fornasero was apparently not aware of Change 15 of the ARB Manual, stipulating that "the ice-protection systems for all four engines must be switched 'ON' during every flight at all times when the indicated outside air temperature is below plus 10°C, except when it is certain that no icing will be encountered"; (2) late anticipation, i.e., Captain Fornasero may not have taken action to arm the system until he observed visible indications of ice accretion; (3) variations in the outside air temperature gauge and the anti-icing thermostatic probe indications due to variations in compressibility, e.g., with indications of plus 5°C, the actual temperatures could have been as low as plus 2°C.

When the flameout occurred, the crew would presumably have followed their current Viscount emergency checklist which called for an immediate relight or a descent to below the freezing level to allow the engine to de-ice naturally. During this time, attempts might have been made to start the flamed out engine or engines. The Board believes that more than one engine must have flamed out before the descent was begun. Had only one engine flamed out, the crew would most likely have continued their flight at the assigned altitude.

Prior to beginning the descent, the aircraft would have been operating near V_{no} -

the normal operating limit speed of 237 knots. During the descent, the throttles of any remaining engines could have been moved toward the closed position and to below the auto-feather arming position. This throttle reduction might also have been required if the aircraft had penetrated an area of light to moderate turbulence en route.

During the descent, the aircraft would be entering progressively warmer air. Any remaining engines would have been operating at a low r.p.m., JPT, and thrust setting, and could have flamed out either because of ice ingestion brought about by the warmer air, or because the anti-icing system was left "ON" during descent to warmer air. Additional drag would have been experienced by the windmilling of the remaining propellers since they would not auto-feather until the throttles were advanced to above 13,400 r.p.m. - the auto-feather range.

Having followed the then used checklist by descending to a lower altitude, the crew would level off after reaching an altitude where the outside air temperature was above freezing and go through the standard drill for relighting without further loss of altitude. As the throttles of the engines that had been operating at the beginning of the descent were advanced, the propellers would auto-feather if they had flamed out due to ice-ingestion during the descent. By this time, the complexity of the situation would have magnified itself to extreme proportions. The airspeed would drop off rapidly, and the aircraft would continue to lose altitude.

The crew would then try jointly to restart any of the engines and to keep control of the aircraft, sacrificing speed for altitude. It is estimated that considerable altitude would have been lost and that three or more minutes would have elapsed since the emergency occurred. During this time numerous efforts would have been made to restart the engines. However, battery energy would have fallen below the required voltage necessary to successfully unfeather a propeller and relight an engine.

A study of numerous Capital Airlines Viscount flights operating at night disclosed that the electrical load being used aboard N 7462 at the time of the emergency was from 500 to 600 amps. If the electrical system were not switched over to the emergency bus system during an emergency in which several engines cease to operate and their propellers automatically feather, all the electrical units in use would continue to draw their energy from the battery. The flight test demonstrated that under similar flight conditions using approximately the same electrical load, the battery energy would fall within 1-1/2 to 2 minutes to below the required voltage necessary to successfully unfeather a propeller and relight its engine. One or more engines running with generator "ON" would supply sufficient electrical energy to feather or relight any of the Viscount engines. A fast windmilling propeller would also furnish enough rotational motion and, in turn, sufficient electrical energy to accomplish propeller unfeathering or engine relight.

If the engines could not be started, efforts could be made to drive the propellers out of feather by windmilling. The aircraft would have to be dived to approximately 150 knots to drive the outboard engines, Nos. 1 and 4, out of feather. Approximately 180 knots of airspeed would have to be attained to drive the inboard engines, Nos. 2 and 3, out of feather.

The fact that Nos. 3 and 4 engines were found to be developing power at impact indicates that these engines were successfully started at some time before impact.

If two of the engines were operating continuously, it is doubtful that the aircraft would have lost altitude since it is certificated to maintain altitude at maximum gross weight with two engines inoperative. Since the investigation revealed power was available on Nos. 3 and 4 engines at impact, and something adverse occurred between 8,000 feet and impact, it is logical to assume if the crew had available to them energy to relight, then relight would have been experienced and sufficient altitude would have been maintained.

No. 4 engine was successfully driven out of feather position and relit. During this time, relighting attempts caused an accumulation of fuel to be deposited in the burners, so that explosive relights occurred, bringing about the noises of engine surging and backfiring heard by the witnesses.

The crew now used full power on the No. 4 engine to assist in checking the severe settling of the aircraft, causing the aircraft to turn to the left. During the last circuit, and as No. 3 engine started, the aircraft was probably operated with full cross controls and was settling rapidly. In order to stop the unwanted turn, it is probable that the crew reduced power on No. 4 engine, with the thought of advancing power on Nos. 3 and 4 engines together after the turn was stopped. Such a reduction of power at a time when full opposite control was being used would arrest the turn but cause greater settling of the aircraft. An application of power was made at or about the time of tree contact. However, it was too late to develop power on No. 3 engine or to supply sufficient power for a climbout. It is possible the crew observed the ground just before impact and applied back elevator pressure on the control column, causing the aircraft to whip-stall. The aircraft then struck the ground before it whipped into the steep nose-down attitude characteristic of the whipstall.

Flight tests disclosed that with three engines inoperative and full power on No. 4 engine, full left rudder and full right aileron, much difficulty was experienced in the attempt to maintain directional control and the result was a slow turn to the left. When power was removed from No. 4 engine, the aircraft would enter a high rate of descent.

Numerous earwitnesses reported hearing "popping noises" or "cutting in and out" of an engine or engines as the aircraft made several circuits to the left just prior to impact. In evaluating the auto-feathering and relighting procedures, the Board believes a logical explanation for these reported sounds can be given. The auto-feather feature is armed and capable of operation throughout the range of throttle positions from cruise to takeoff - that is, from 13,400 to 14,500 r.p.m. Below cruise throttle position the throttle switches are open, and the auto-feather feature is ineffective. During rapid acceleration the throttles may reach the position at which these switches are set before the torque pressure has had time to rise above 50 p.s.i. However, in the event the relight is not completed the propeller will go toward the feather position. This process is of very short duration and does, in fact, assist the acceleration.

If partial relight should occur, the throttle may be closed and opened rapidly to about 12,000 r.p.m., to effect a complete relight. In the event this action does not achieve a complete relight, it is then necessary to refeather and wait two minutes for fuel drainage before repeating the unfeather procedure. However, in an emergency, successive attempts to relight may be made.

In the event the high pressure cock is not placed in the feather position subsequent to the propeller auto-feathering, fuel could collect in some parts of the combustion chamber. In addition, if the throttle were partially open and the unfeathering switch operated to obtain unfeathering oil pressures and ignition, there could be an explosive relight. This action could be repeated a few times within the 30 seconds relight-time-switch cycle, thus giving rise to a "popping noise."

As stated earlier, the Board believes Nos. 1 and 2 propellers were auto-feathered - a condition which is substantiated by the fuel found in the snout area of the No. 3 combustion chambers of these engines. Furthermore, fuel in this location supports the assumption that the high pressure cock was in the open position.

The Board believes that the most likely sequence of events, based on the reported engine sounds and the known procedures for accomplishing a relight of Dart engines, consisted of an attempt to drive the propellers out of feather by windmilling, followed by multiple attempts to relight one or more engines. Successive relights were interrupted by auto-feather action initiated by premature advancing of the throttle prior to complete lightup.

During the investigation, No. 3 engine igniter points were found considerably eroded. This raised some speculation as to whether such a condition could be a factor in delaying relight of No. 3 engine until just prior to impact. The igniter boxes of all four engines were bench-checked and found to be capable of operation. Investigation revealed that the erosion noted on these igniter points was the result of time in service since overhaul and not a contributing factor in this accident.

During the investigation of this accident, the Board discovered that the Change No. 15 to the ARB Flight Manual had been disseminated to all Viscount operators for a period of 19 months prior to the accident and included in the manuals carried in the Capital Airlines' Viscounts, but the material had not been incorporated into the Capital Airlines Flight Training Manual furnished to all the Capital Viscount pilots and utilized in the ground school instruction for Viscount aircraft. Nor was this material incorporated in the pilot emergency and routine checklists. The Board's investigation of this accident revealed further that at the time of and subsequent to the accident, many Viscount pilots of Capital Airlines were not aware of the change to arm the power unit ice-prevention system at plus 10°C instead of at plus 5°C, despite the fact that this change became effective July 1958.

Conclusions

After an evaluation of all evidence, the Board concludes that Capital Airlines Flight 20 of January 18, 1960, entered an area of weather en route to Hopewell VOR which was conducive to icing; that because of certain discrepancies in the anti-icing instructions, several engines flamed out due to delayed arming of the Viscount engine ice-protection system; that in efforts to relight the several engines which had flamed out, the remaining engines flamed out because of intake icing and actuation of auto-feathering. Several moments passed during which all four engines' propellers feathered, airspeed decreased, and considerable altitude was lost. Engine rotation ceased for a sufficient time to cause a drop in battery electrical energy to below the required voltage necessary to successfully unfeather a propeller and relight its engine.

Additional altitude was lost when the aircraft was dived in efforts to drive the propellers out of feather by windmilling. The crew was eventually successful in its attempts to drive No. 4 propeller out of feather and relight the engine.

Full power was used on No. 4 engine in an attempt to check the severe settling of the aircraft. With this asymmetrical power configuration, it is believed that directional control was not maintained with the use of full opposite controls. As a result, and, since the aircraft was apparently being flown near V_{mca} speed,[2] several circuits to the left were made in the impact area. An application of power was made at or about the time of tree contact. The aircraft struck the ground with no forward velocity.

The weather at the time of departure from Washington National Airport was suitable for the dispatching of the flight. There was no evidence of mechanical hindrance or failure in the engines, propellers, or accessories, and no indication of mechanical hindrance in the relighting of the engines. There were no structural or control system problems. The aircraft was adequately equipped to cope with both airframe and induction ice accumulations.

Subsequent to this accident, the Board made several operational studies of inflight procedures practiced by Capital Airlines Viscount pilots in connection with the use of the engine ice-protection system. As a result of these studies, the Board, in a letter dated July 14, 1960, disclosed to the Federal Aviation Agency that Capital Airlines Viscount pilots were still not following proper procedures relating to the use of the ice-protection system.

As a result of this accident, Capital Airlines dropped the phrase "descend to warmer climate for relight" from its emergency checklist and instructed its Viscount pilots that relight could be accomplished at any altitude if the proper drill were followed. Capital Airlines also adopted a system of checking pilots to ascertain that they had the benefit of the latest operating information.

Probable Cause

The Board determines the probable cause of this accident was the delayed arming of the engine ice-protection systems while flying in icy conditions, resulting in the loss of engine power and attendant electrical energy required to unfeather propellers and relight sufficient engines to maintain flight.

BY THE CIVIL AERONAUTICS BOARD:

/s/ ALAN S. BOYD
Chairman

/s/ G. JOSEPH MINETTI
Member

/s/ ROBERT T. MURPHY
Member

/s/ WHITNEY GILLILLAND
Member

/s/ CHAN GURNEY
Member

2/ V_{mca} = minimum airborne control airspeed of approximately 108 knots for Flight 20's configuration and weight.

S U P P L E M E N T A L   D A T A

Investigation and Hearing

The Civil Aeronautics Board was notified of this accident shortly after occurrence. An investigation was conducted immediately in accordance with provisions of the Federal Aviation Act of 1958. A public hearing was held at Richmond, Virginia, May 3 and 4, 1960.

Air Carrier

At the time of this accident, Capital Airlines, Inc., was a Delaware Corporation and maintained its principal offices in Washington, D. C. The corporation held a current certificate of public convenience and necessity issued by the Civil Aeronautics Board to engage in the transportation of persons, property, and mail. It also possessed a valid air carrier operating certificate issued by the Federal Aviation Agency.

On June 1, 1961, Capital Airlines, Inc., was merged with United Air Lines, Inc.

Flight Personnel

Captain James B. Fornasero, age 50, was employed by Capital Airlines on April 1, 1941, and was promoted to captain February 14, 1946. He held a valid airman certificate with an airline transport pilot rating for airplane multiengine land, and DC-3, DC-4, Lockheed Constellation, and Vickers Viscount aircraft type ratings. He had accumulated 20,850 flying hours, of which 3,560 were in the Viscount. His last first-class physical examination, taken on November 23, 1959, was satisfactory with no waivers. His last semi-annual proficiency check of July 19, 1959, and his last line check of January 12, 1960, were satisfactory.

Copilot Philip H. Cullom, Jr., age 36, was employed by Capital Airlines on July 14, 1953. He held a valid airman certificate with an airline transport pilot rating for airplane, multiengine land, and aircraft type rating for the DC-3. He had accumulated a total of 5,215 flying hours, of which 2,952 were as copilot on the Viscount. His last first-class physical examination, taken on July 24, 1959, was satisfactory with no waivers. His last instrument and copilot check was satisfactorily passed on August 26, 1959.

Hostess Diane M. O'Donnell, age 26, was employed March 6, 1959. Hostess Brigitte F. H. Jordt, age 23, was employed March 25, 1959.

The Aircraft

Vickers-Armstrongs Viscount, model 700D, N 7462, bore manufacturer's serial number 217. It was manufactured February 2, 1957, and purchased by Capital Airlines on March 2, 1957. Since new the aircraft had accumulated 9,247 hours. The aircraft was powered by Rolls-Royce Dart engines, model 510, which were equipped with Rotol propellers, model R 130/4-20-4/12E with RA 25842 blades.